The use of ultrasound guidance in lumbar neuraxial blockade

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Neuraxial blockade of the lumbar spine is the standard of care for obstetric procedures (eg. Cesarean section) and orthopedic operations of the lower extremities when general anesthesia is contraindicated or unnecessary.¹ A local anaesthetic is injected epidurally (in epidural anaesthesia) or intrathecally (in spinal anaesthesia) at a level of the lumbar spine that is presumed to be below the conus medullaris, in order to minimize the risk of accidental trauma to the spinal cord.² Generally, this corresponds to the L3-4 vertebral interspace.

The current technique for locating the L3-4 interspace is by palpation of external anatomic landmarks. It is approximated by the height of Tuffier's line, an imaginary line connecting the highest points of the two iliac crests. This level is estimated to be either the L3-4 interspace or the L4 spinous process. The needle is inserted at this level at the center of the spine. Insertion into the epidural space is confirmed by loss of resistance to an injection of saline or air, and insertion into the intrathecal space is confirmed by the return of cerebrospinal fluid through the needle.

Unfortunately, evidence suggests that the technique of locating interspace levels by external palpation presents serious safety issues. As demonstrated by Broadbent et al.² in an observational study comparing external palpation to magnetic resonance imaging (MRI), identification of interspace using external palpation could be quite inaccurate. In fact, levels were identified correctly only 29% of the time, and this inaccuracy was especially pronounced in obese patients. In most of the errors, the physician underestimated the interspace level. This meant that the level they actually identified was higher than the level that they thought was identified (eg. believed that the level was L3, when it was actually L2), which can potentially lead to unintentional puncture of the spinal cord during injection.

This substantial risk of underestimating vertebral levels has indeed resulted in accidental spinal punctures in the clinical setting. Moen et al.³ conducted a review of neurological complications associated with lumbar neuraxial blockade in Sweden from 1990 to 1999, and found that nine patients suffered from traumatic spinal cord lesions following the procedure. In eight of these cases, the physician thought that the puncture was performed at a safe interspace level, exemplifying an underestimation of level. The sequelae for five of these patients was severe pain, and for the remaining three, cauda equina syndrome. Hamandi et al.⁴ reported five cases in the United Kingdom of irreversible neurological impairment resulting from puncture of the spinal cord during lumbar neuraxial

blockade. In all of the cases, the physician underestimated the level of interspace punctured.

The incidence of spinal cord trauma associated with lumbar neuraxial blockade, most of which caused by underestimation of spinal level, is not high (1 in 190000, based on studies so far) as the majority of incorrect punctures are benign.³ However, when it does occur, the consequences that follow such a complication can be devastating for both the patient and his/her family. Over the last decade, more and more physicians are beginning to perform their lumbar neuraxial blockade procedures under ultrasound guidance. Evidence suggests that ultrasound guidance, which is currently the only modality of guidance for these procedures other than palpation, makes lumbar neuraxial blockades more accurate and potentially safer. A detailed procedural description of ultrasound-guided lumbar neuraxial blockade can be found in a review by Chin et al.⁵

Current research shows that identification of vertebral levels using ultrasound guidance carries much more accuracy than through external palpation. In an observational study by Watson et al.⁶ of patients undergoing spine MRI, ultrasound-guided identification of the L3-4 interspace was accurate 76% of the time. Furness et al.⁷ compared palpation-guided to ultrasound-guided identification of lumbar interspaces in patients scheduled for spine X-ray, and found that the ultrasound-guided method carried an accuracy of 70%-90%, while the palpation-guided method was only 30%-40% accurate.

Clinically, performing lumbar neuraxial blockade under ultrasound guidance appears to generate more favourable patient outcomes than the conventional method. Grau et al.^{1,8} conducted several randomized clinical trials comparing palpation-guided vs. ultrasound-guided lumbar neuraxial blockade with respect to both technical and patient outcomes. In one study performed on parturients undergoing conventional delivery or Cesarean section,⁸ it was found that the ultrasound-guided method involved fewer puncture attempts than the palpation-guided method. A puncture attempt was defined as any puncture from outside the body, or any protraction and redirection of the needle within the body. Thus, this study showed that an ultrasound-guided procedure required less needle manipulations due to accidental misplacement, therefore holding the potential to minimize the risk of unintentional injury to the patient. Interestingly, patients in the ultrasound group also experienced better analgesia compared to those in the control group. This may be attributed to a greater accuracy in injection, such that the drug distributes itself equally on both sides of the injection site. Pa-

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tients in the ultrasound group suffered from fewer side effects and overall, were significantly more satisfied than the control. Another study by Grau et al.¹ concerned combined spinal-epidural anaesthesia performed on parturients scheduled for Cesarean section. Again, the ultrasound-guided method involved fewer puncture attempts than the palpation-guided method, and patients in the ultrasound group reported greater satisfaction. While these data pertain solely to obstetrical patients, it does not seem unreasonable to extend the results to orthopedic patients as well.

In light of the severe and irreversible neurological complications that can occur with spinal cord trauma due to the inaccuracy of needle placement in conventional palpation-guided lumbar neuraxial blockade, and the findings that ultrasound-guided lumbar neuraxial blockade is more accurate and leads to greater patient satisfaction, it is likely that the ultrasound-guided method will replace the current protocol as the standard of care in the future.

With regards to challenges, an obvious concern with ultrasound-guided lumbar neuraxial blockade is potential cost. Another obstacle is patient safety. While ultrasound scanning itself is generally regarded as safe, it is possible for the transmission gel to leak into the puncture site.⁵ The safety implications of this are currently unclear and require careful observation. Finally, it is recognized that the real-time ultrasound-guided procedure is fairly difficult, requiring stabilization of the ultrasound probe on the patient's back and dexterity with needle angle changes. Furthermore, the population in whom the conventional technique poses difficulties, such as the morbidly obese, may also have poorly visible structures on ultrasound. Thus, students practising on patients may inflict serious harm. Fortunately, these challenges can potentially be surpassed by having students initially train on spine phantoms,⁹ low-cost simulations where a spinal model is immersed in a solid gel medium. Spine phantoms have been shown to possess similar echogenic properties as human bodies, and can be constructed to mimic a wide variety of patient characteristics (eg. obesity, kyphosis, scoliosis, etc.).

Currently, there is a lack of research to assess the safety and cost-effectiveness of ultrasound-guided lumbar neuraxial blockade, and few studies to directly compare it against the conventional method in terms of patient outcomes. One major reason is that utilization of ultrasound for lumbar neuraxial blockade is adopted by only a few practitioners around the world.⁵ More large-scale randomized clinical trials are required to generate a greater amount of rigorous evidence supporting the higher safety of the technique. Thus, there are still several hurdles that must be leaped before ultrasound-guided lumbar neuraxial blockade can be established as the standard of care, and one must be patient. However, the already existing demonstration of its higher accuracy combined with the relatively low cost of ultrasound scanning makes the situation very encouraging.

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